(12) UK Patent Application (19) GB (11) 2 303 888 (13) A

(43) Date of A Publication 05.03.1997

(21) Application No 9515881.2

(22) Date of Filing 02.08.1995

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(51) INT CL^6
F16J 15/10

(52) UK CL (Edition O)
F2B B1B B1J
F1V VCDD V106 V111
U1S S1987

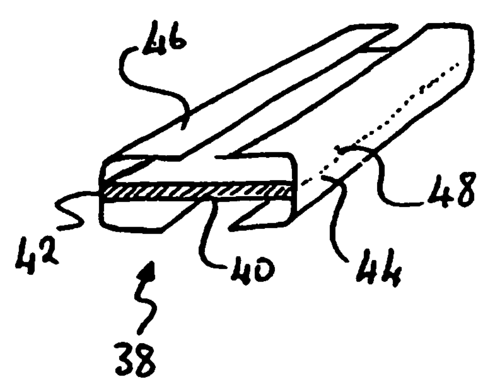
(56) Documents Cited
GB 2240822 A GB 2182399 A GB 1580884 A
US 4537024 A US 4127359 A

(58) Field of Search
UK CL (Edition N) F1V, F2B
INT CL^6 F01D 11/00, F16J 15/00
ON LINE DATABASES:WPI,CLAIMS

(54) **Platform seal**

(57) A strip seal for use as a vane platform interface seal, for example, in the combustor nozzle outlet vane annulus of a gas turbine aeroengine, comprises a central thin flexible strip 40 with inward facing C- or U-shaped flexible members 46, 48 running along its longitudinal edges. The shaped edge members are fitted snugly into the normal confronting grooves of the vane interface and provide a gas tight seal. The construction and materials make the seal strip sufficiently compliant to accommodate various platform offsets including skewed offsets.

FIG 3a



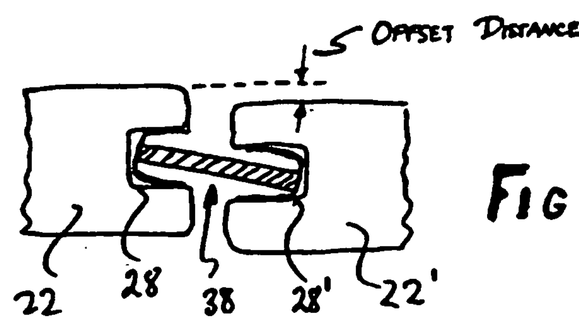


FIG 4

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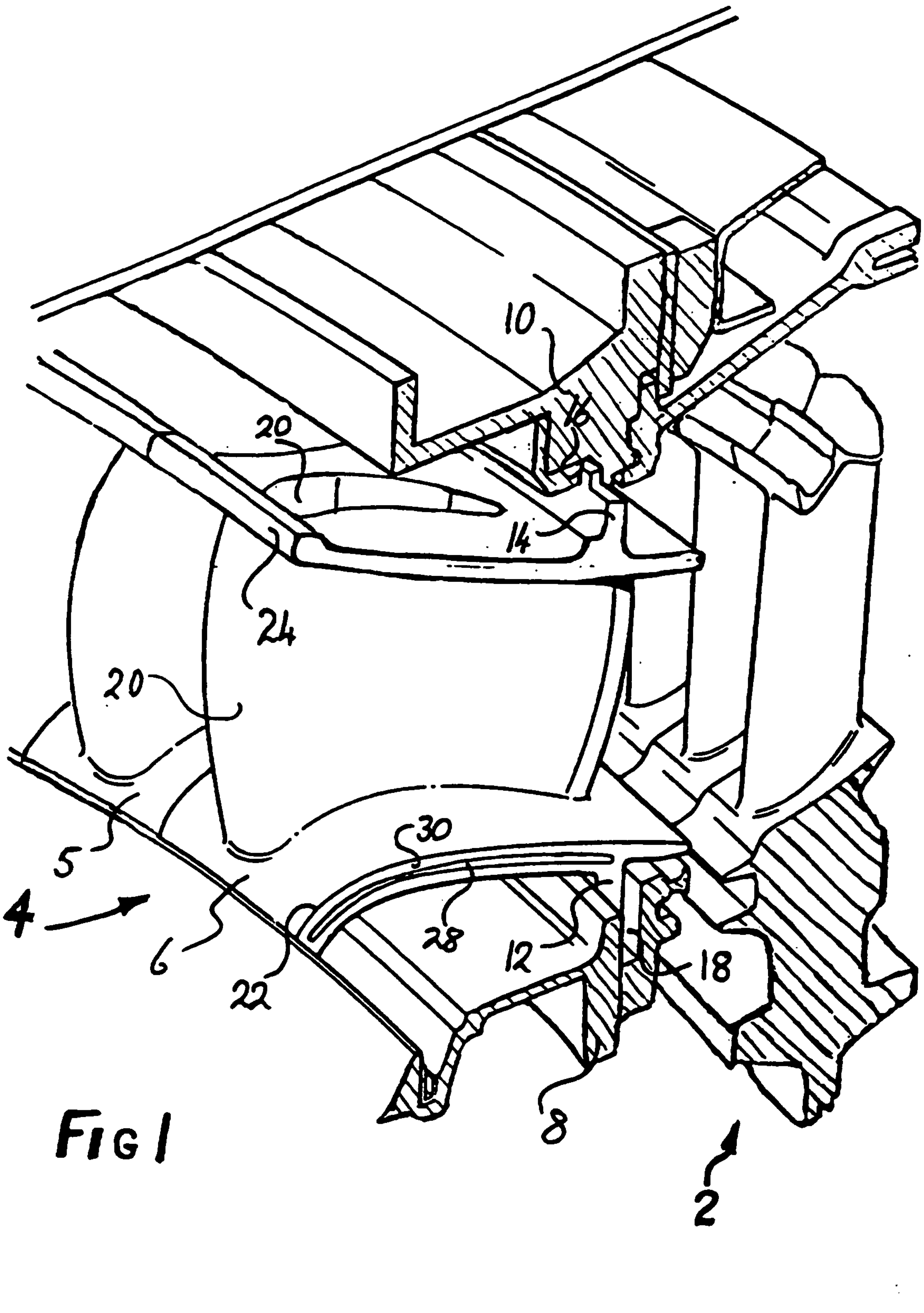


Fig 1

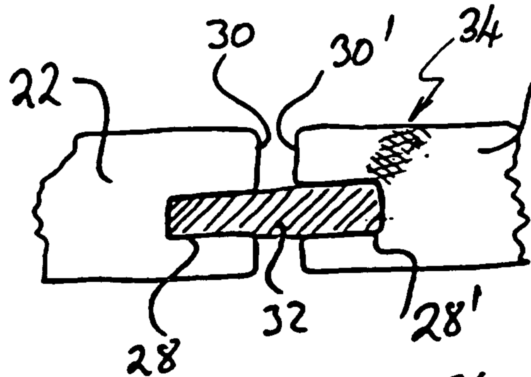


FIG 2a

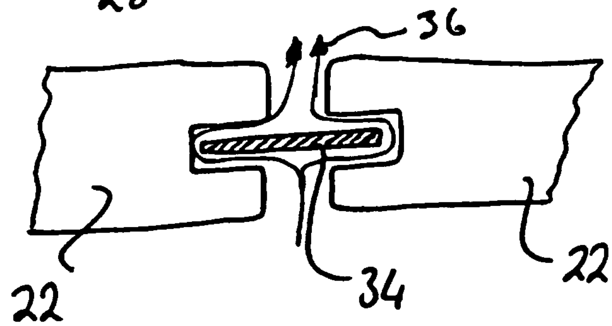


FIG 2b

FIG 3a

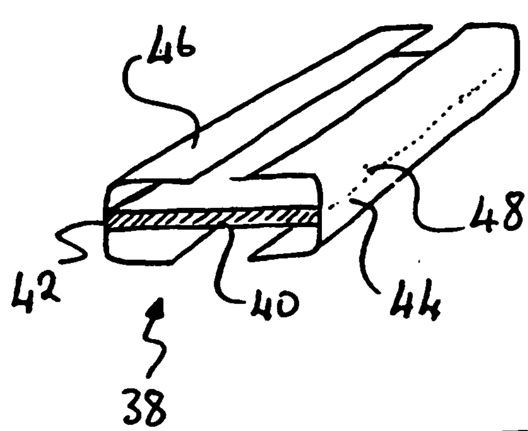
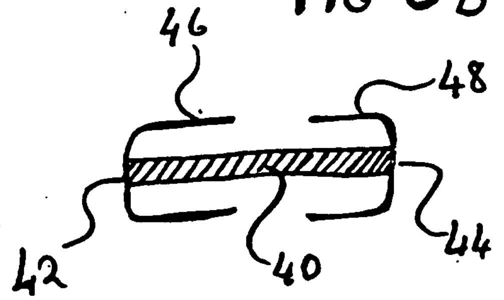


FIG 3b



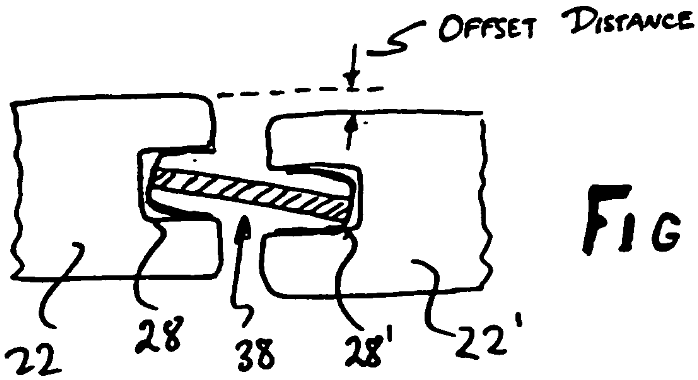


FIG 4

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PLATFORM SEAL

The invention concerns a seal arrangement for sealing an interface between abutting components. In particular it relates to seal strips for sealing the space between abutting vane platform edges in a gas turbine engine.

Seal arrangements or seal strips of the kind referred to are used to seal gaps, joints, interfaces and the like through which internal engine cooling air may escape. Of course, the seals also prevent hot gas ingestion which, particularly between turbine stages would cause overheating, unwanted thermal expansion and premature fatigue. Strip seals of present interest are used to seal gaps between platforms and, in their simplest basic form, are simple strips of metal inserted into groves in confronting faces of abutting components. Now, because of variations due to manufacturing tolerances etc a certain amount of misalignment of the grooves is to be expected and typically the grooves may be offset or skewed. Usually this is dealt with by allowing a degree of clearance of the seal strips within the seal grooves and tolerating stresses and strains which occur at various regions of the engine envelope as tolerance gaps close and components "bottom" as a consequence. Metal and metal alloy components are normally able to absorb a certain amount of such stresses but ceramic materials are much more brittle and vane platforms, for example, are prone to fracture where seal strips have exerted high loads on the components.

The present invention is intended to overcome these drawbacks by providing a seal strip design which avoids loading, at least to a very great extent, the margins of the seal grooves and nevertheless is able to provide an effective seal with low leakage characteristics.

According to the present invention, therefore, there is provided a seal arrangement for sealing an interface between abutting components comprising a groove formed in each of the confronting faces of the components and a seal strip located in said grooves

which extend substantially the length of the component faces characterised in that the seal strip carries along both longitudinal edges concave edge portions adapted to be inserted into said grooves.

Preferably the concave edge portions are adapted to engage the walls of the grooves and, furthermore, the concave edge portions are compliant.

In a preferred form of the invention the concave edge portions are formed separately as C- or U-shaped members and joined to the longitudinal edge of the seal strip.

The invention and how it may be carried into practice will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a partly dissembled turbine entry stage revealing a side edge face of an inlet guide vane platform,

Figure 2a shows a section through a known thick seal strip,

Figure 2b shows a section through a known thin "leaky" seal strip,

Figure 3a shows a perspective view of a seal strip according to the invention,

Figure 3b shows a sectional view of the seal strip of Figure 3a, and

Figure 4 shows the seal strip installed between two misaligned platform grooves.

There is shown in Figure 1 a segment of a turbine rotor stage generally indicated at 2, which is immediately downstream of an annular array of turbine entry, inlet guide vanes a segment of which is indicated at 4. These guide vanes define the exit from

an annular combustor (not shown) but which would be located towards the left of the drawing, thus defining the gas flow direction from left to right. The guide vane array 4 comprises a multiplicity of individual vane segments of which two neighbouring segments 5,6 are shown. The whole array of segments is mounted between radially inner and outer casing assemblies 8,10 respectively. The style of mounting is of a well known kind in which the segments carry circumferentially extending flange portions 12,14 which slot into circumferential grooves 16,18 thereby providing axial location of the vane segments, in combination with a degree of freedom for radial movement. Circumferential location is taken care of by the abutment of neighbouring segments in the annular array.

Each vane segment, taking segment 6 in Figure 1 as an example, comprises a generally radial aerofoil section 20 which extends between inner and outer platform sections 22,24 respectively. The flange portions 12,14 are formed integrally with the platform sections 22,24. In the particular example illustrated the vanes are cooled internally by cooling air which flows through a hollow interior cavity 26 extending through the platforms and aerofoil section. Plenum chambers may be formed in spaces between the platform sections 22,24 and the adjacent casing sections 8,10 for the supply and collection of this cooling air. Thus, it will be immediately apparent that leakage of cooling air from under these platforms into the gas will result in its loss from the internal air cooling system. Such leakage may easily come about through spaces between neighbouring vane platforms 22 and 24.

Gaps between the vane platforms arise as a result of several factors, for example: the platforms are deliberately dimensioned to avoid compressive loading during assembly, and the opening up of gaps due to differential thermal expansion effects. The normal technique for minimising the amount of this leakage is by the use of thick or thin seal strips of the kind shown in either Figures 2a of Figure 2b inserted into opposing grooves in the confronting platform side faces of adjacent vane segments. In

Figure 1 one of these grooves is indicated at 28 extending along the mid-region of side face 3 of the inner platform 22 of vane segment 6. As will be apparent from Figures 2a and 2b a pair of confronting side faces 30,30' of neighbouring vane platforms 22,22' formed with opposing grooves 28,28'. Both grooves have identical dimensions in the illustrated example, but this is not necessarily always so. Into these pairs of grooves it is commonly known to insert a seal strip to reduce leakage through the gap between the faces 30,30'. In both examples the seal strip is plain and nominally flat seal strip, although as will be appreciated from Figure 1 the grooves 28,28' may curve in one direction along the lengths of the platform edge.

The seal strip 32 of Figure 2a is thick and fills the width of the grooves 28,28' although the width of the seal strip, that is the distance between its layer edges, need not fill the depth of the grooves. This thick strip, at assembly temperature, is a push fit into the grooves leaving no gaps for leakage gas to flow around the strip edges. The strip may be a looser fit at room temperature with differential thermal expansion taking account of clearance distances. Upon assembly the seal strips hold the platform edge grooves 28,28' in alignment but a spread of manufacturing tolerances in nominal dimensions can result in neighbouring platforms and grooves being offset. As a result shear forces may be applied to the seal strips by the platform margins, during engine operation these forces may be increased by thermal expansion. These forces give rise to stress concentrations in the cross-hatched regions 34 of the platform edge martins - only one such region 34 is indicated in Figure 2a but it will be readily understood that different offsets produce stress concentrations in different regions. It will also be understood that these offsets need not be constant nor parallel. For example, the grooves 28,28' may be skewed so that the offset distance and hence the stress forces change along the length of the vane platform. Metal alloy vane segments usually possess sufficient inherent strength and platform thickness to absorb these stress concentrations. However, ceramic and composite material components are less able to tolerate these loading

conditions and fractures can occur in relatively highly stressed regions such as 34. It is therefore desirable to avoid such regions by designing around the problems.

Figure 2b shows a section through a platform interface, in which parts like those in Figure 2a have like references, including a thin seal strip 34. This thin seal strip has dimensions, particularly in thickness, less than the combined dimensions of the grooves 28,28'. However, as illustrated by the arrows 36 this arrangement inevitably suffers from substantial leakage around the edges of the strip itself, but the strip does not exert stress forces on the platform edges and does not, in the case of brittle vane materials, give rise to the possibility of consequential fractures.

The seal strip 38 illustrated in Figure 3a and 3b is intended to improve on the sealing properties of the thin seal strip of Figure 2b while retaining much of its low-stress inducing characteristics while avoiding the drawbacks of the arrangement of Figure 2a. The seal strip 38 comprises a relatively thin metal strip 40 of, as shown in the drawings, a basic rectangular outline. Along either longitudinal edge 42,44 of the strip 40 there are concave edge portions 46,48 respectively which are adapted for insertion into platform interface grooves 28,28' see Figure 4.

In the illustrated example the edge portions 46,48 are formed on thin metal or metal alloy sheet formed into C- or U-shaped elongate members and attached symmetrically along their axes of symmetry to the longitudinal edges 42,44 of the strip. The preferred method of attachment is by linear welds, eg by laser welding, but the members could be brazed-on or attached to any other suitable means. The members 46,48 are attached facing each other, that is with their limbs pointing towards inwardly and overlapping the margin of the strip 40. Alternatively the longitudinal side members 46,48 may be formed integrally with the strip 40. In yet another arrangement the seal 38 is formed as upper and lower mirror images and joined back-to-back so that

each half has inwardly turned margins along either longitudinal edge and the central strip 40 is formed of double thickness material. It will be apparent that the composite strip seal 38 may take a number of forms and configurations and the illustrated embodiment is described by way of example only.

In use the strip seal 38 of Figures 3 and 3b is inserted into the grooves 28,28' as shown in Figure 4. The seal construction is sufficiently compliant to accommodate significant offset of skewed grooves which not only change along the length of the grooves but which may also change in displacement. The distance between the outer surfaces of the members 46,48 is chosen to be slightly greater than the width of the grooves 28,28' so that the seal fits snugly into the grooves.

The limbs of the edge members 46,48 are free to bend relative to the central strip 40 to follow the walls of the grooves 28,28', thereby avoiding a leakage gas path around the edges of the strip 40 through the interface grooves. However, the composite strip seal 38 is sufficiently compliant to accommodate various platform offsets and offsets which vary between the leading and trailing edges of the platforms, without comprising its sealing abilities. Preferably not only are the members 46,48 sufficiently compliant to accommodate a varying offset and relative groove angles but also the central strip 40 is also flexible. Thus a seal may be maintained along the whole length of the strip seal. Note that static pressure head on the sides of the seal may tend to expand the members 46,48 urging their limbs against the groove walls further aiding sealing.

CLAIMS

1 A seal arrangement for sealing an interface between abutting components comprising a groove formed in each of the confronting faces of the components and a seal strip located in said grooves which extends substantially the length of the component faces characterised in that the seal strip carries along both longitudinal edges concave edge portions adapted to be inserted into said grooves.

2 A seal as claimed in claim 1 wherein the concave edge portions are adapted to engage the walls of the grooves.

3 A seal as claimed in claim 1 or claim 2 wherein the concave edged portions are compliant.

4 A seal as claimed in any preceding claim wherein the concave edge portions are formed separately as C- or U-shaped members and joined to the longitudinal edges of the seal strip.

5 A seal as claimed in any preceding claim wherein the concave edge portions are joined to the longitudinal edges of the seal strip in a symmetrical fashion.

6 A seal as claimed in any preceding claim wherein the seal strip and the concave edge portions are formed of metal or metal alloys and are joined by welding.

7 A seal strip as claimed in any preceding claim wherein the seal strip comprises an elongate flat member which is relatively thin relative to the depth of the grooves.

8 A seal strip substantially as hereinbefore described with reference to the accompanying drawings.

8

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Sea. report)**	Application number GB 9515881.2
Relevant Technical Fields (i) UK Cl (Ed.N) F2B, F1V (ii) Int Cl (Ed.6) F16J 15/00, F01D 11/00	Search Examiner A R MARTIN
	Date of completion of Search 17 OCTOBER 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE: WPI, CLAIMS	Documents considered relevant following a search in respect of Claims :- ALL CLAIMS

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2240822	(GEC) see Figure 4	Claim 1 at least
X	GB 2182399	(ROLLS ROYCE) see Figure 7	Claim 1 at least
X	GB 1580884	(ROLLS ROYCE) see Figure 3	Claim 1 at least
X	US 4127359	(MTU) see Figure 4A and Claim 1	Claim 1 at least
X	US 4537024	(SOLAR)	Claim 1 at least

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